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FUEL EQUIVALENTS FOR FUELS USED BY USSR RAILROADS

/An explanation of the letters designating types of coals is appended. 7

Under operating conditions on the railroads it is often necessary to make calculations in which it is convenient to use the so-called fuel equivalents, which permit the various types of fuel to be equated and to replace each other according to a convention, e.g., equivalents can be used when comparing fuel expenditures per index of work, when making up estimates or orders for fuel required, when determining the cost of freight carrying, etc. To clarify the nature of the equivalents and the method of determining them it is necessary first to acquire at least a general familiarity with the basic characteristics and properties of more important types of fuel used to fire locomotives.

Such knowledge is also very important in explaining the influence of the type of fuel on the amount of steam produced by the boiler and on the locomotive capacity actually realized.

Fuel equivalents show what quantity of 7,000-calorie equivalent fuel must be burnedina standard boiler with an efficiency of 1.0 to replace a unit of a given real fuel measured by weight (wood is measured by volume) in a real boiler with an efficiency of less than 1.0.

Equivalents are determined by the formula $\partial = \frac{Q_H^{\mu} \mathcal{N}_K}{7000}$ where ∂ is the equivalent in relation to 7,000-calorie fuel, Q_H^{μ} is the lower calorific value (in calories per kilogram) of the working fuel calories per kilogram) of the working fuel, and $\eta_{\mathcal{K}}$ is the gross boiler efficiency characteristic for the given type of fuel.

The values Q_H^P and η_K for each fuel were determined on the basis of laboratory data of the All-Union Heat Engineering Institute and of the actual quality of the fuel received by the People's Commissariat of Transportation in 1935-36.

The translation of real fuel to equivalent fuel is done by multiplying the absolute weight quantities of the real fuel by the corresponding equivalents shown in the tables below.

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When stoker firing is used, the equivalents for was and long-flame coals have been established without regard to whether the coals are burned in pure form or in mixture. For the other types of fuel the equivalents have been established taking into account the burning of these fuels in mixture.

For hand firing, equivalents have been established for fat, sintering, long-flame, gas, and coking coals independently of their being burned in pure form or in mixture. For the other types, equivalents have been determined taking into account their being burned in mixture.

It must be kept in mind that since the efficiency of the boiler is a function of \mathbb{Z}_{K} (the amount of steam in kilograms produced per square meter of heating surface) and y (the amount of fuel in kilograms expended per hour per square meter of firebox grating), the magnitude of the equivalent of a given fuel must also depend on \mathbb{Z}_{K} and y.

For instance, tests run in 1942 to determine equivalents for Kuznetsk coals on the Tomsk Railroad System with a series Em locomotive gave the following results:

Type of Coal	<pre>Zm (hourly expenditure of steam, in kg, in machine of locomotive per sq m of heating surface)</pre>								
	<u>25</u>	<u>30</u>	<u>35</u>	40	45	<u>50</u>			
PS Anzhero-Sudzhensk	0.718	0.705	0.690	0.674	0.649	0.612			
PS Kemerovo	0.699	0.606	0.689	0.675	° 0.655	0.624			
PS Prokop°vevsk	0.639	0.631	0.622	0.612	0.602	0.589			

Under operating conditions, however, the value Q_H^2 for a given type of fuel will not remain constant, but will vary in dependence on the ash content, moisture content, etc.

Therefore, the equivalents shown in the following tables should be regarded only as orienting points corresponding to the average conditions of locomotive operation.

The following table gives the fuel equivalents for stoker-fired locomotives in relation to 7,000-calorie fuel used in fireboxes having standard grates and domes, and where Z_K equal 60 kilograms per square meter per hour. Z_K is the lower calcrific value of the burning mass, expressed in calories per kilogram.

	Table 1				
Fuel	Type	Qĭ _	Q_H^P	<u> 7</u> K	<u> </u>
Donets coal	D ·	7,340	5,560	0.645	0.512
Donets coal	G	7,730	6,410	0.596	0.546
Donets coal	PZh	8,060	6,770	0.548	0.525
Donets coal	PS	8,220	6,830	0.450	0.439
Donets coal	PS P/K	8,245	6,246	0.400	0.378

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Table 1 (contd)					
Fuel	Type	QĤ	QH	<u> 71K </u>	_ _
Donets coal	т	8,280	7,210	0.288	0.297
Donets briquette	Mospino station	8,320 *	7,570	0.528	0.571
Donets triquette	Khanzhen kovo sta tion		7,790	0.528	0.588
Donets briquette	Yenakiye station	ro 8,290	6,980	0.510	0.509
Donets anthracite	AM	8,000	6,690	0.593	0.567
Donets anthracite	ARSE	7,970	6,590	0.523	0.492
Moscow coal	Avg	6,730	2,890	0.478	0.197
Kizelovskiy coal	G/PZn	7,830	5,690	0.630	0.512
Chelyabinsk coal	Avg	6,710	4,130	0.585	0.345
Karaganda coal	PZh/PS	8,020	5,220	0.635	0.564
Karaganda Fedorcvskiy coal	PR	6,855	4,530	0.612	0.396
Siberian Leninsk (Kol'- chugino) coal	G	7,880	6,765	0.610	0.590
Siperian Leninsk (Kol²- chugino) coal	D	7,400	6,275	0.610	0.594
Siberian Prokop'yevek coal	SS	8,150	6,795	0.612	0.587
Siberian Kiselevsk coal	SS	7,,980	6,870	0.595	0.564
Siberian Anzhero - Sudzhensk coel	PS	8,3#0	7,225	0.450	0.444
Siberian Kuybyshev (Araliche- skiy Rayen) coal	T	8,250	6,690	0.372	0.356

Tables 2 and 3 show the equivalents for fuel for (1) hand-fired locomotives in relation to 7,000-calorie equivalent fuel, applicable for fireboxes with standard grates having a small useful section and with standard domes, and (2) petroleum, the fireboxes having a lining and a dome with an overlapping of 60 percent, with Z_{KH} (number of kilograms of steam brought to a heat content of 640 calories per kilogram, produced per square meter of heating surface per hour) equaling 50 kilograms per square meter per hour.

Table 2. Liquid Fuel

Fuel	Engler	QH	QH	NK	<u> </u>
Firebox mazut Firebox mazut	20-40 60-80	9,810 9,690		0.740 0.691	1.014 0.935

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Table 3 Coals

Fuel	Type	Q¥	QH	NK.	
Group 1. Brown Coals (Moscow type)					
Tovarkovskiy coal	BK, BR, BO	6,314	2,900	0.578	0.240
Pobedinskiy coal	BK, BR, BO	6,530	3,160	0.578	0.261
Borbizhovskiy coal	BK, BR, BO	6,372	3,978	0.578	0.246
Obolenskiy coal	BK, BR, BO	6,343	2,873	0.578	0.237
Shchekino coal	BK, BK, /sig BO	7 6,440	2,987	0.540	0.230
Avg quality coal	BK, BR, BO	6,433	3,013	0.578	0.249
Ural Bogoslovskiy coal	BR	6,280	3,650	0.578	0.301
Ural-Chelyabinsk coal	BK, BR	6,710	4,130	0.585	0.345
Central Asia Kizil- Kiya coal	В	6,600	4,310	0.540	0.332
Srednyaya Sulyukta coal	В	6,790	4,920	0.540	0.379
Sredniy Shurab coal	В	6,655	4,135	0.530	0.319
Karaganda-Fedorovskiy coal	BR	6,855	4,520	0.585	0.379
Siberian Chernovskiy Tarbagatay coal	В	6,980	4,770	0.585	0.400
Siberian Chernovskiy Tarbagatay coal	В	6,805	3,870	0.578	0.320
Far East Artem coal	BK, BR, BO	6,530	3,922	0.578	0.234
Far East Kivdinskiy coal	BK, BR, BO	6,155	3,118	0.540	0.245
Far East Raychikhinsk coal	BR, BK, BO	6,248	3,367	0.540	0.260
Far East Tavrichanka coal		6,880	4,890	0.578	0.404
Ukrainian Aleksandriya coal		6,165	1,780	0.500	0.127
Ukrainian Kirovskiy coal		6,320 "	1,485	0.500	0.106
Ukrainian Zvenigorodka coal		6,120	2,080	0.500	0.149
Group 2. Long-Flame Coals					
Donets coal	D	7,340	5,560	0.600	0.477
Central Asia Berchogur coal	D	7,530	4,475	0.580	0.471
Siberian Chernogorodskiy (Khakass) coal	D	7,1420	5,760	0.600	0.494
			4.550	1421	

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Table 3 (contd)					
<u>Fuel</u>	<u>Type</u>	QH	QJ.	Zr_	 _
Siberian Cheremkhovo coal	D	7,420	5,660	0.600	0.485
Siberian Leninsk (Kol'- chugino) coal	D	7,400	6,275	0.600	0.538
Group 3. Gas Coals					
Donets coal	G	7,730	6,410	0.615	0.563
Donets coal	Gp/k	7,610	5,770	0.600	0.494
Ural Kizelovskiy coal	G/PZh	7,830	5,990	0.600	0.488
Transcaucasus Tkvarcheli coal	G/PZh	7,880	4,980	0.580	0.409
Transcaucasus Tkvarcheli coal	G	7,340	4,730	0.580	0.392
Central Asia Kok-Yangak coal	G	7,250	5,180	0.580	0.425
Central Asia Chok-pakskiy coal	G	7,700	6,400	0.615	0.562
Siberian Leninsk (Kol°chugino) coal	G	7,880	6,765	0.615	0.594
Siberian Bukachacha coal	g/PZh	7,450	5,735	0.600	0.492
Spitzbergen coal	G	7,915	6,445	0.600	0.552
Group 4. Steam-Fat Coals					
Donets coal	PZh	8,060	6,710	0.660	0.633
Donets coal	PZhp/k	8,015	6,240	0.630	0.562
Donets coal	K	8,140	6,390	0.655	0.598
Siberian Kemerovo coal	PZh	8,205	6,950	0.660	0.655
Siberian Osinovskiy coal	PZh	8,080	6,635	0.660	0.625
Far East Suchan coal		8,070	6,505	0.660	0.613
Karaganda coal	PZh, K	8,030	5,710	0.660	0.538
Group 5. Steam Sintering Co	oals				
Donets coal	PS	8,220	6,830	0.650	0.634
Donets coal	PSp/k	8,245	6,624	0.625	0.591

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Table 3 (contd)		_			
Fuel	Type	Q_H^2	Q_{H}^{G}	7K	_ _ _
Siberian Anzhero-Sudzhensk coal	PS	8,340	7,225	0.650	0.671
Siberian Kiselevsk coal	SS	8,980	6,870	0.625	0.613
Siberian Kemerovo coal	PS	8,160	6,810	0.650	0.632
Siberian Prokop'yevsk coal	SS	8,011	6,795	0.625	0.607
Karaganda coal	PS	8,010	6,210	0.650	0.577
Group 6. Lean Coals					
Donets coal	T	8,230	7,210	0.577	J.594
Siberian Kuybyshev (Aralichev skiy Rayon) coal	т	8,250	6,690	0.577	0.551
Group 7. Briquettes					
Donets briquette	Mospino station	8,320	7,570	0.610	0.660
Donets briquette	Khanzhen- kovo station	8,380	7,790	0.610	0.679
Donets briquette	Yenakiyevo station	8,290	6,980	0.600	0.598
Group 8 Anthracites					
Donets anthracite	AP, AP /sic/	8,040	7,180	0.630	0.646
Donets anthracite	AM	8,000	6,690	0.597	0.571
Donets anthracite	ARSh	7,970	6,590	0.571	0.538
Donets anthracite	AS	7,980	6,580	0.402	0.378
Donets anthracite	ASSh	7,430	6,410	0.402	0.368
Ural Yegorshino anthracite	AR	8,030	6,150	0.571	0.502
Ural Bredy anthracite		7,840	5,755	0.571	0.469
Group 9. Shales	•				
Veymarnskiy shales		6,288	2,578	0.500	0.284
Gdov shales		7,990	2,170	0.500	0.155

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Table 3 (contd)			·			
<u>Fuel</u>	Type	QH	QH	7K		•
Kashin shales		6,500	1,710	0.480	0.117	
Undorskiy shales		5,500	1,733	0.580	0.119	
Savel'yevdkiy shales		6,490	1,650	0.480	0.113	
Group 10.						
Material from smokeboxes of steam locomotives		7,800	4,000	0.289	0.165	
	Table	4. Wood and Pe	eat			
Fuel 1		Quantity of U	seful Cal	lories	nx) (Volume)
Group 1. Wood (by volume)					·	
With 25% moisture content					1.,63	· · · · · · · · · · · · · · · · · · ·
Deciduous		1,236,655			0.588	0.105
Coniferous		1,186,335			0.550	0:093
Mixed		1,238,965			0.558	0.099
With 35% moisture content				•		
Deciduous		1,199,960			0.581	0.100
Coniferous		1,152,330			0.540	0.089
Mixed		1,203,320			0.546	0.094
With 45% moisture content						
Deciduous	**	1,149,625			0.571	0.094
Coniferous		1,106,600			0.530	0.084
Mixed		1,154,925			0.537	0.088
<u>Fuel</u>		QH	QP	7K	<u> </u>	ight)
Group 22. Wood (by) weight)				ι		
With 25% moisture content						
© Deciduous		4,420	3,115	0.588	0.262	
Coniferous		4,555		0.550	0.253	
Mixed		4,510		0.558	0.254	

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Table 4 (contd) Fuel	QH	Q.F.	<u> 27 K</u>	Э (weight)
With 35% moisture content				
Deciduous	4,420	3,620	0.581	0.217
Coniferous	4,555	2,705	0.540	0.208
Mixed	4,510	2,680	0.546	0.209
With 45% moisture content				
Deciduous	4,420	2,125	0.571	0.178
Coniferous	4,555	2,200	0.530	0.166
Mixed	4,510	2,175	0.537	0.167
Group 3				
Fagots	4,420	2,826	0.400	0.162
Haloxylon (straw)	4,555	3,210	0.500	0.230
Machine-cut peat with 30% moisture content	5,335	3,220	0.530	0.244
Machine-cut peat with 45% moisture content	5,335	2,400	0.500	0.171

APPENDIX

In the tables, types of coaldesignated by letters are as follows:

- B (buryy) brown coal. Since Moscow area coal has relatively constant qualitative characteristics, it is subdivided only according to size, as follows:
 - K (krupnyy) large
 - 0 (orekh) nut
 - MS (meloch's semyachkom) fines with pea size
 - R (ryadovoy) run-of-the-mine.
- D (dlinnoplamennyy) long-flame
- G (gazovyy) gas.
- PZh (parovichnno-zhirnyy) steam-fat.
- K (koksovyy) coking.
- PS (parovichno-spekayushchiysya) steam-sintering.
- SS (slabospekayushchiysya) weakly sintering.
- T (toshchiy) lean.
- A Anthracite

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AP (plitnyy) - slab

AK (krupnyy orekh) - large nut

AM (melkiy orekh) - small nut

AR (ryadovoy) - run-of-the-mine.

AS (semyachko) - pea

ARSh (ryadovoy so shtybom) - run-of-the-mine with dross

ASSh (semyachko so shtybom) - pea with dross

p/k indicates a mixture of slab and large nut.

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